NASA CR-
144365

# RESEARCH, DEVELOPMENT AND APPLICATION

# OF

# NONCOMBUSTIBLE BETA FIBER STRUCTURES


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J. J. Dillon

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OWENS-CORNING FIBERGLAS CORPORATION


Final Report

July, 1975

Contract No. NAS-9-6988



NASA
Johnson Space Center
Structures and Mechanics Division

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# FOREWORD

This report was prepared by the Textile Support Group, Owens-Corning Fiberglas Corporation, under Contract No. NAS-9-6988. It covers the work accomplished during the period April 17, 1967, through December 31, 1974, and is the final report.

The contract was initiated by the Crew Systems Division, NASA - Johnson Space Center, Houston, Texas, and later transferred to the Structures and Mechanics Division. Mr. Jack Naimer was the Technical Monitor.

The program was performed under the technical direction of Mr. E. S. Cobb. Mr. J. J. Dillon was the Principal Investigator.

## 1. ABSTRACT

Owens-Corning Fiberglas Corporation (OCF) conducted research and development to utilize Beta* fiber textile structures in spacecraft and crew systems applications. Beta fiber was selected as the primary material for flexible fibrous structures used in spacecraft and crew systems applications in the Apollo program because it was noncombustible in a 100 percent oxygen atmosphere up to 16.5 psia. Additionally, it met NASA criteria for outgassing, toxicity, odor, and crew comfort; and possessed sufficient durability to last through the mission.

Many commercial applications of Beta fiber existed at the start of the program. However, a major technical effort was necessary to expand existing technology and to design the specific textile materials which could be efficiently used in these unique applications. The program encompassed the following categories of effort:

1. Study of spacecraft applications in conjunction with NASA and NASA contractors.
2. Design of Beta fiber textile structures to meet the requirements. Over 150 structures were developed.
3. Selection of surface treatments -- finishes, coatings, and printing systems -- to impart the required durability and special functional use to the textile structures.

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* Registered trademark, Owens-Corning Fiberglas Corporation

4. Development of sewing and fabrication techniques.

5. Execution of extensive testing and evaluation programs and development of production sources for Beta textile structures. These required close and extensive working relationships with NASA and NASA contractors.

A contract technical performance appraisal is given in Reference 4G:

> "At the start of the program, the spacecraft included more than 150 different textile configurations in the forms of fabrics, tapes, webbings, braids, sleeving, sewing thread, non-woven pads, filters, and so forth. During the course of this program, the necessary items and configurations that had to be made of Beta fiber were defined, and participating contractors were made knowledgeable on the characteristics and methods of fabricating end-use items with Beta fiber materials. The adaptation and successful fabrication of the majority of these items in Beta fiber glass is considered a major technical achievement."

## II. INTRODUCTION

Immediately following the tragic Apollo fire at Cape Kennedy in February, 1967, NASA's Johnson Space Center (JSC) undertook a twofold program to prevent recurrence. The first element of this program was the elimination, where possible, of all sources of ignition, and the isolation of the remaining ignition sources from combustible materials. The second element was the replacement of all possible combustible materials within the spacecraft with noncombustible materials. The described contract effort addressed the isolation of ignition sources and the replacement of combustible materials.

The basic requirements for materials in spacecraft and crew systems applications include noncombustibility in a 100 percent oxygen atmosphere up to 16.5 psia, and sufficient durability to last through the mission. Because it meets these criteria (References 1 and 2), Beta, a fine filament glass fiber produced by OCF, was selected as the primary material candidate for flexible fibrous structures in spacecraft and crew systems of the Apollo and Spacelab programs. Additionally, Beta met NASA criteria for outgassing, toxicity, odor, and crew comfort.

A Beta filament diameter is nominally 14 HT* (3.8 microns), or 1/4 denier. This fineness of filament diamete gives Beta textile structures greater softness, flexural endurance, abrasion resistance, and durability than other noncombustible inorganic fibers.

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* Hundred thousanths of an inch

## III. DISCUSSION AND RESULTS

### A. Baseline Study

The first task was a detailed study of the textile structures and materials then in use in spacecraft and crew systems applications. Through consultation with NASA-JSC personnel and their contractors; study of specifications; and observation of applications; the characteristics, performance requirements, and fabrication techniques for end-items were determined. Test methods were selected or devised to measure the appropriate properties to assist in material evaluations. Several hundred end-items became candidates for redesign in Beta fiber. These required several types of textile structures, viz., woven and knitted, nettings, tapes, webbings, braids, lacings, cords, sleeves, sewing threads, nonwoven felts, and pads.

### B. Substitution Program

While some existing Beta fiber fabrics were incorporated into the Apollo program at the outset of the contract effort, an extensive program was required to:

a. Provide technical direction in fabric design, selection, application, modification, and fabrication techniques both at the NASA-JSC and their contractors.

b. Develop special Beta fiber surface treatments, structures, and sewing and fabrication techniques.

c. Make recommendations, manufacture prototypes, and provide specifications, testing, and test procedures.

Additionally, supply sources were developed for the quantities of various Beta fiber textile structures required to support the Apollo and Spacelab programs.

OCF laboratory and pilot plant facilities were extensively utilized in the design, testing, and prototype production of woven fabrics, tapes, webbings, and nonwoven felts. Assistance was provided by various textile industry producers in the design and prototyping of knits, braids, cords, lacings, and sewing threads.

Over 150 textile structures using Beta fiber were specified as candidate materials for spacecraft and crew systems applications.

1. <u>Textile Structure and Surface Treatment Selection and Application</u>

   The successful application of Beta fiber textile structures in the Apollo and Spacelab programs depended on the suitability of the surface treatments used. These treatments -- finishes, coatings, and printing systems -- were used to impart the required durability and functionality to the structures. Surface treatment program activity involved material, amount, application method, and matrix form selection. All treated materials had to meet the noncombustibility and durability specifications.

   a. <u>OCF Style X4190B</u>

      OCF Style X4190B (J. P. Stevens Style 15035) fabric was selected for general use in spacecraft applications such as garments, stowage sacks, kit bags, and hose covers. The fabric is a dense

90 x 65 plain weave, woven from B 150 1/0 yarns warp and fill, and weighs 6.25 oz/sq yd.

For some of the applications, the fabric was treated with a standard, OCF silicone finish designated OCF F017A (J. P. Stevens 9362). Typical physical properties of the X4190B/F017A fabric are shown in Appendix A.

For other end-items, it became apparent that the X4190B/F017A fabric durability and abrasion resistance were insufficient. To enhance these properties, a number of coatings were tried. Carboxy nitroso rubber, Fluorel (fluorinated rubber), and Teflon coatings were used in a number of end-items. Teflon coating was the most common surface treatment used in this program. These Teflon-coated fabrics were used principally for bags placed around electrical connectors, for the outer layers of containers, and for the encapsulation of flammable flight items. In the tissue container, for example, protection was provided against flame impingement at 1800°F in an oxygen atmosphere for 8 minutes without charring the facial tissues. In some cases, reflective layers of aluminum foil and asbestos were incorporated in the inner layers of a container.

The volume requirements for X4190B style fabric were filled by J. P. Stevens and Company. The Teflon coatings on the X4190B type fabrics were applied by E. I. duPont, Fairfield, Connecticut,

or Dodge Industries, Hoosick Falls, New York. Typical physical properties of the X4190B Teflon-coated fabric are shown in Appendix A.

b. OCF Style X4484

Style X4484 Beta fabric was developed by OCF in response to a need for enhanced breathability and surface durability in the space suit (ITMG) outer layer, and was subsequently used in many other applications in the spacecraft. The fabric is 6 oz/sq yd, plain weave, 64 x 64, woven from Beta 150 1/0 yarn. Before weaving, the yarn was heat cleaned, Teflon coated, and sintered. This fabric was breathable, and more flexible than the Teflon-coated X4190B fabric.

The bulk of the Teflon-coated yarns were produced by Engineered Yarns, Coventry, Rhode Island. All the fabric was produced in the OCF pilot plant. Typical physical properties of the X4484 fabric are shown in Appendix A.

In the development of the Teflon-coated X4190B fabric and the yarn for X4484 fabric, a process for coating, heat setting, and heat cleaning was developed in the OCF Ashton Laboratory. The process is described in U. S. Patent No. 3,653,949 (Reference 5).

2. Textile End-Item Development

Typical of the Beta textile structures that were used in the Apollo program are:

--- X4190B and X4484 fabrics described above

--- Beta marquisette used as a spacer material between aluminized Kapton layers in the ITMG superinsulation system

--- Beta cords, braids, webbings, tapes, and lacings used as accessories on the spacesuit, and on crew provision and survival items

--- A double knit fabric (designated FG-104), made with bulked Beta yarn and F017A finish, used as a nonflammable spacecraft insulation, a cushioning material, and as a substrate for nonflammable fluorinated rubber coating. Covers made of this coated material were used around spacecraft hoses.

--- Beta wire-tie cord used extensively in wire bundles throughout the spacecraft

--- NASA emblems, flags, mission emblems, name plates, and PLSS labels screen printed on Beta fabric with nonflammable print paste

--- Nylon-coated, Beta sewing thread manufactured by Belding Corticelli

--- Several constructions of Raschel knitted Beta nettings used as debris nets

--- Several nonwoven Beta fiber felts and batts produced to NASA contractor specifications. These were produced in the OCF laboratory and in commercial mills.

--- Beta yarns used in the base of a special nonmetallic fastening system (Astro-Velcro)

3. <u>Sewing and Fabrication Techniques</u>

Techniques were developed for sewing and fabricating Beta fiber materials into end-item structures. OCF arranged for a sewing consultant to visit NASA's and NASA contractors' sewing rooms, to instruct the supervisors and operators in handling Beta textiles, and to recommend fabrication and sewing equipment. General recommendations for handling, cutting, and sewing Beta textiles were compiled in an OCF Technical Report (contained in Reference 3). As a result of the instructions and use of the Technical Report, end-item contractors were able to fabricate many complicated, special Beta textile structures.

4. <u>Testing</u>

An extensive testing effort was involved in the program to substitute Beta textile structures for flammable textile items in the spacecraft. This testing effort encompassed materials property determination and end-item qualification. Testing agencies included both the OCF Ashton and Granville laboratories, NASA (particularly for 100 percent oxygen environment) and many NASA contractors.

5. <u>Contractor Participation</u>

OCF worked closely with NASA and NASA contractors to provide end-items meeting performance specifications. Applications were investigated and the feasibility of using Beta fiber structures was studied in each case. Recommendations were made and end-item development and fabrication assistance supplied.

Many required Beta fiber structures were fabricated in-house, tested, and supplied in pilot plant quantities by OCF. Other sources of textile structure fabrication services were established by OCF as required.

Sources of production quantities of Beta fiber structures were developed by OCF for supply to NASA end-item fabricators.

Where special consultant services were required by NASA, NASA contractors, or textile suppliers or fabricators, OCF developed the source of information and arranged for the services.

The names and addresses of the NASA locations, NASA contractors, textile structure suppliers, and end-item fabricators with whom OCF worked during the contract are in Appendix B.

6. <u>Dissemination of Technology</u>

A conference was held in 1970 to present to the private sector (industry and civilian), and other Government agencies, NASA's technology developments that provide improved fire safety in domestic and commercial fields. The Apollo/Beta applications were reviewed, and published in the proceedings (Reference 4).

## REFERENCES


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3. Anonymous, Apollo Flame Resistant Substitute Materials Program, MSC-NASA, October, 1967

4. Proceedings of NASA Conference on Materials for Improved Fire Safety - Held at MSC-NASA, Houston, Texas, May, 1970

    A. Katsikas, C. J., et al, Manned Spacecraft Nonmetallic Materials Flammability Selection Criteria and Requirements, Section 2

    B. Bricker, R. W., et al, Apollo Command Module and Lunar Module Mock-up Flammability Tests, Section 5

    C. Dawn, F. S., Nonmetallic Materials Development for Spacecraft Applications, Section 6.

    D. Supkis, D. E., Development and Application of Fluorel, Section 7

    E. Radnofsky, M. J., New Materials for Spacecraft, Aircraft, and Other Applications, Section 10

    F. Craig, J. W., Apollo Spacecraft Nonmetallic Materials Applications, Section 14

    G. Naimer, Jack, Apollo Applications of Beta Fiberglas, Section 16

    H. Dawn, F. S., et al, The Apollo Spacesuit Materials, Section 17

5. U. S. Patent 3,653,949, Dillon, Coated Fabrics and Methods of Applying Coatings Thereto, April 4, 1972

Appendix A

Physical Properties of Beta Textile Structures

Typical Physical Properties of X4190B Teflon-Coated Beta Fabric at

Two Coating Levels

Note: Specimens were conditioned and tested at 72°F and 65% R.H.

| Property | 1 Warp | 1 Fill | 2 Warp | 2 Fill | No. of Tests | Test Method |
|---|---|---|---|---|---|---|
| **Fabric Weight** . . . . . oz/sq yd | 6.6 | - | 7.8 | - | 3 | ASTM-D579 |
| **Yarn Count** . . . . . . yarns/in | 92 | 54 | 92 | 64 | 5 | ASTM-D579 |
| **Ignition Loss** . . . . . . . . % | 12.2 | - | 20.4 | - | 2 | OCF-DF510 |
| **Elmendorf Tear** . . . gms/sheet | 3610 | 5130 | 2343 | 2230 | 5 | CCC-T-191B-5132 |
| **Tongue Tear** . . . . . . . . lbs | 4.5 | 4.3 | <1 | <1 | 3 | ASTM-D2262 |
| **Stoll Abrasion** . . . . . cycles | | | | | | |
| Bar (1 lb ld. 2 lb tension) | 77 | 45 | 298 | 213 | 5 | ASTM-D1175-64T-B |
| Flat (1 lb ld. 3 lb pressure) | 282 | - | 738 | - | 5 | ASTM-D1175-64T-A |
| **Seam Strength** . . . . . . . lbs | 14.4 | 28.3 | 17.0 | 27.2 | 5 | ASTM-D434 |
| Yarn Slippage (1.4"). . . . . | None | None | None | None | 5 | ASTM-D434-42 |
| Yarn Slippage (1/8"). . . . . | 11.5 | 27.5 | None | None | 5 | ASTM-D434-42 |
| **Taber Abrasion** (500 gms/CS 17 Wheel). . . . . . . . . cycles | | | | | | |
| Appearance failure . . . . . | 56 | - | 79 | - | 5 | ASTM-D1175-64T-D |
| Fabric Failure. . . . . . . . . | 351 | - | 1267 | | 5 | ASTM-D1175-64T-D |
| **Break Strength** (Instron 0.6 IPM) lbs/in. | | | | | | |
| Original . . . . . . . . . . | 115 | 74 | 90 | 79(1) | 5 | ASTM-D1682-1R-E |
| Roller Crease . . . . . . . . . | 114 | 70 | 80 | 48(1) | 5 | OCF-DF515 |
| **Air Permeability** . . . . . . . cu ft/min/sq ft (20" W.P.D.). . . . . . . . . . . | 30.7 | - | 3.94 | - | 5 | ASTM-D737 |

(1) Cut strip method was used as yarns were too brittle to ravel

Typical Physical Properties of X4190B Fabric/F017A Finish

Note: Specimens were conditioned and tested at 72°F and 50% R.H.

| Property | Data | No. of Tests | Test Method |
|---|---|---|---|
| Fabric Weight . . . . . . . . . . . oz. sq yd | 6.23 | 2 | ASTM-D579-49 |
| Ignition Loss . . . . . . . . . . . . % | 0.32 | 2 | OCF-DF510 |
| Dry Tumbler . . . . . . . . . . . . hrs | 3.5 | 1 | OCF-DF506 |
| Breaking Strength . . . . . . . . . lbs/in. | | | OCF-DF509 |
| Warp . . . . . . . . . . . . . . . . | 145 (1) | 5 | |
| Fill . . . . . . . . . . . . . . . . | 169 (1) | 5 | |
| Tongue Tear . . . . . . . . . . . . . . lbs | | | ASTM-2262-64 |
| Warp (2) . . . . . . . . . . . . . . | 4.1 | 3 | |
| Fill (2) . . . . . . . . . . . . . . | 4.2 | 3 | |
| Seam Strength (Type A Nylon Thread) . . lbs | | | ASTM-D434-42 |
| Warp . . . . . . . . . . . . . . . . | 44.0 | 5 | |
| Fill . . . . . . . . . . . . . . . . | 48.2 | 5 | |
| Yarn Slippage (Type A Nylon Thread) . . . lbs | | | ASTM-D434-42 |
| 1/4" Slippage: | | | |
| Warp . . . . . . . . . . . . . . . | None | 5 | |
| Fill . . . . . . . . . . . . . . . | None | 5 | |
| Yarn Distortion (5# load, 2 rubs) . . inches | | | ASTM-D1336 |
| Warp . . . . . . . . . . . . . . . . | .01 | 4 | |
| Fill . . . . . . . . . . . . . . . . | 0 | 4 | |
| Stoll Flat (1# load 3# pressure) . . . cycles | 330 | 5 | |
| Stoll Bar (1# load 2# tension) . . . . cycles | | | ASTM-D1175B |
| Warp . . . . . . . . . . . . . . . . | 88 | 5 | |
| Fill . . . . . . . . . . . . . . . . | 82 | 5 | |
| Taber Abrasion (500 gm load, CS 17 Calibrase) . . . . . . . . . . . . cycles | 449 | 5 | |
| Wyzenbeek Seam (2# load, 3# tension) cycles | | | ASTM-D1175-OCF |
| Warp . . . . . . . . . . . . . . . . | 350 | 3 | |
| Fill . . . . . . . . . . . . . . . . | 275 | 3 | |
| Wyzenbeek Flat (2# load, 2# tension) cycles | | | ASTM-D1175C |
| Appearance Failure: | | | |
| Warp . . . . . . . . . . . . . . . | 1900 | 3 | |
| Fill . . . . . . . . . . . . . . . | 1733 | 3 | |
| Fabric Failure: | | | |
| Warp . . . . . . . . . . . . . . . | 2500 | 2 | |
| Fill . . . . . . . . . . . . . . . | 2950 | 2 | |
| Thickness . . . . . . . . . . . . . mils | | | |
| 5/8 psi . . . . . . . . . . . . . . | 8.05 | 10 | ASTM-D579-49 |
| 3.4 psi . . . . . . . . . . . . . . | 7.86 | 10 | ASTM-D579-49 |
| Yarn Count . . . . . . . . . . yarns/inch | | | ASTM-D579-49 |
| Warp . . . . . . . . . . . . . . . . | 92 | 5 | |
| Fill . . . . . . . . . . . . . . . . | 64 | 5 | |

(1) Specimens broke at the jaw

(2) Diagonal tear

Typical Physical Properties of X4484 Fabric/Teflon-Coated Yarn

Note: Specimens were conditioned and tested at 72°F and 65% R.H.
Sample Description: B 150 1/0 heat cleaned, Teflon coated, sintered yarn woven into 64 x 64 X4484 fabric

| Property | Data Warp | Data Fill | No. of Tests | Test Method |
|---|---|---|---|---|
| Fabric Weight . . . . . . . . . . . . oz/sq yd | 6.18 | - | 2 | ASTM-D579 |
| Ignition Loss . . . . . . . . . . . . . . % | 17.86 | - | 2 | OCF-DF510 |
| Yarn Count . . . . . . . . . . . . yarns/inch | 66 | 64 | 5 | ASTM-D579 |
| Thickness . . . . . . . . . . . . . . . mils | 7.6 | - | 5 | CCC-191B-5030 |
| Breaking Strength . . . . . . . . . lbs/inch | | | | |
| Original . . . . . . . . . . . . . . . . . | 208 | 212 | 5 | ASTM-D1682-1C-E |
| Roller Crease . . . . . . . . . . . . . . | 177 | 209 | 5 | ASTM-D1682-1C-E |
| Stoll Edge Abrasion | | | | |
| (1# ld. 0 Emery Paper) . . . . . cycles | 155 | 131 | 5 | ASTM-D1175 |
| Stoll Bar Abrasion (1# ld. 2 lb tension) cycles | 216 | 165 | 5 | ASTM-D1175-61T-B |
| (1# ld. 4 lb tension) cycles | 59 | 52 | 5 | ASTM-D1175-61T-B |
| Stoll Flat Abrasion . . . . . . . . . cycles | | | | |
| (1 lb. load, 3 lb. pressure). . . . . . . | 208 | - | 5 | ASTM-D1175-61T-A |
| Taber Abrasion (500 gms/CS 17 Wheel) cycles | 972 | - | 5 | ASTM-D1175-61T-D |
| Wyzenbeek Flat Abrasion . . . . . . . cycles | | | 3 | ASTM-D1175-61T-C |
| (3 lb load, 4 lb tension) | | | | |
| 240 Grit Emery . . . . . . . . . . . . . | 67 | 28 | | |
| Steel Screen . . . . . . . . . . . . . . | 98000 | 24333 | | |
| Wyzenbeek Seam Abrasion . . . . . . . cycles | | | 3 | ASTM-D1175-61T-C |
| (2 lb load, 3 lb tension) | | | | |
| 240 Grit Emery . . . . . . . . . . . . . | 15 | 15 | | |
| Steel Screen . . . . . . . . . . . . . . | 7300 | 1700 | | |
| Tumbler Abrasion . . . . . . . . . . . . hours | 2 (3) | - | 1 | OCF-DF506 |
| Seam Strength . . . . . . . . . . . . . . lbs | 40 | 43 | 5 | ASTM-D434-42 |
| Yarn Slippage (1/4 inch) . . . . . . . . . . lbs | None | None | 5 | ASTM-D434-42 |
| Yarn Slippage (1/8 inch) . . . . . . . . . . lbs | 20 | 28 | 5 | ASTM-D434-42 |
| Yarn Distortion . . . . . . . . . . . inches | | | | ASTM-D1336-64 |
| 2 lbs 2 rubs . . . . . . . . . . . . . . | 0 | 0 | | |
| 5 lbs 2 rubs . . . . . . . . . . . . . . | .06 | 0 | | |
| MIT Flex (1.5 kg ld .59" spec .01 head) cycles | 12708 | 18048 | 5 | OCF |
| Air Permeability (0.5 w.p.d.) . . . . . . . . | | | | OCF |
| cu ft/min sq ft . . . . . . . . . . | 18.3 | - | 5 | ASTM-D737 |
| Elmendorf Tear . . . . . . . . . . . . gms/sheet | 5910 | 5778 | 5 | CCC-T191B-5132 |
| Tongue Tear (1) . . . . . . . . . . . . . . lbs | 19 | 20 | 5 | ASTM-D2262 |
| Mullen Burst . . . . . . . . . . Mullen Points | 482 | - | 5 | OCF-DF511 |
| Durability to Machine Wash ( 2) | | | | |
| Cycles to Failure . . . . . . . . . . . . | 19 (3) | - | 1 | OCF-DF516 |
| Dimensional Change . . . . . . . . . . . . . % | | | | |
| After 1X . . . . . . . . . . . . . . . . | -3.70 | -3.09 | | |
| After 10X . . . . . . . . . . . . . . . . | -5.46 | -4.58 | | |
| After Failure . . . . . . . . . . . . . . | -6.72 | -5.88 | | |

(1) Diagonal tears
(2) Fabric was washed on the W & W cycle for 8 minutes, warm wash, cold rinse, and the high water level. Ivory Liquid detergent was used in the wash water.
(3) Yarn shifting changed the original smooth appearance to a puckered appearance.

Appendix B

NASA, NASA Contractors, and Textile Suppliers

## Appendix B

## NASA, NASA Contractors, and Textile Suppliers

### NASA

L. B. Johnson Space Center
Houston, Texas 77058

Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

### NASA Contractors

FRL
1000 Providence Highway
Dedham, Massachusetts 02026

McDonnell-Douglas Astronautics Company East
St. Louis, Missouri 63166

Rockwell International Corporation (North American Aviation)
12214 Lakewood Blvd.
Downey, California 90241

Lockheed Aviation Corporation
Sunnydale, California 94088

ILC Industries, Inc.
350 Pear Street
Dover, Delaware 19901

David Clark Company
360 Franklin Street
Worcester, Massachusetts 01601

Grumman Aircraft Engineering Corporation
Bethpage, Long Island, N. Y. 11714

Hamilton-Standard
Division of United Aircraft Corporation
Windsor Locks, Connecticut 06096

Weber Aircraft
2820 Ontario Street
Burbank, California 91503

Whirlpool Corporation
300 Broad Street
St. Joseph, Michigan 49085

Arthur D. Little Company
Acorn Park
Cambridge, Massachusetts 02104

Airesearch Mfg. Company
2525 West 190th Street
Torrance, California 90509

Mosites Rubber
P. O. Box 2115
Fort Worth, Texas 76101

Textile Suppliers

(Fiberglas Weavers)

J. P. Stevens & Company
Stevens Towers
1185 Avenue of Americas
New York, N. Y. 10036

Hess Goldsmith
Division of Burlington Industries
1345 Avenue of Americas
New York, N. Y. 10019

Uniglass Industries
Division of United Merchants & Manufacturers, Inc.
1407 Broadway
New York, N. Y. 10018

Clark-Schwebel Fiber Glass Corporation
50 Rockefeller Plaza
New York, N. Y. 10020

(Knitters)

Lebanon Knitting Mills
School Street
Pawtucket, R. I. 02860

Heidenberg Textile Fabrics Company
Railroad Avenue
Closter, New Jersey 07624

Van Craft Knitting Mills
678 High Street
Central Falls, Rhode Island 02863

(Tapes and Webbings)

Sherman Textile Corporation
92 Pleasant Street
Pawtucket, Rhode Island 02860

Bally Ribbon Mills
Bally, Pennsylvania 19503

Murdock Webbing
27 Foundry Street
Central Falls, Rhode Island 02863

Carolina Narrow Fabric Company
1036 North Chestnut Street
Winston Salem, North Carolina 27102

Talon Corporation
Arch Street
Meadeville, Pennsylvania 16335

(Braids and Cords)

FWF Industries
P. O. Box 6445
Providence, Rhode Island 02904

Valrayco, Inc.
P. O. Box 455
Essex, Connecticut 06426

Bentley Harris Mfg. Company
Conshohocken, Pennsylvania

(Coated Yarns and Fabrics)

Engineered Yarns, Inc.
372 Main Street
Coventry, Rhode Island 02816

Dodge Industries
Hoosick Falls, New York 12090

E. I. duPont de Nemours & Company, Inc.
85 Mill Plain Road
Fairfield, Connecticut 06430

Raybestos Manhattan, Inc.
North Charleston, South Carolina 29406

Thiokol Chemical Corporation
Denville, New Jersey 07834

Reeves Brothers
Rutherfordton, North Carolina 28139

Kenyon Piece Dye Works
Kenyon, Rhode Island 02836

(Garments and Fabrication)

B. Welson & Company
104 Ledyard Street
Hartford, Connecticut 06114

Fyrepel, Inc.
27th Street & Buckeye Avenue
Newark, Ohio 43055

L & W Foster Sportswear
Hancock & West Mooreland Streets
Philadelphia, Pennsylvania 19144

Atlas Underwear Corporation
Piqua, Ohio 45356

J. D. Plant Company
East Route 1
Branford, Connecticut 06405

American Velcro, Inc.
Dow Street
Manchester, New Hampshire 03103

(Printing of Emblems and Flags)

Screen Print Corporation
Industrial Park
Coventry, Rhode Island 02816

(Fiber Specialties)

Monsanto Company (Durette)
800 North Lindbergh Avenue
St. Louis, Missouri 63166

Travis Fabric Company (Fypro)
1071 Sixth Avenue
New York, New York 10018

(Nonwovens)

Southern Mills, Inc.
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